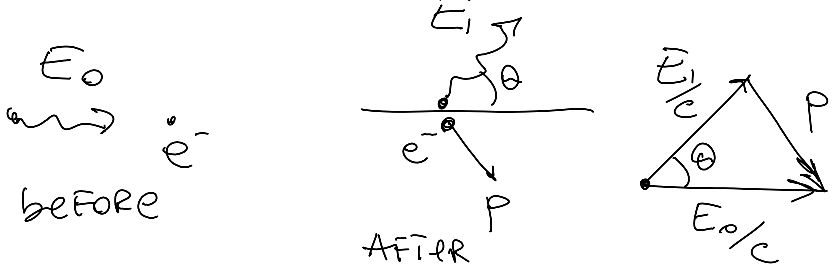
# Homework #7

Tuesday, June 01, 2010
2:16 PM

Extra: Re-derivation of Compton Scattering as shown in class:




"No free lunch" momentum:

$$p^2 = \left(\frac{E_1}{c}\right)^2 + \left(\frac{E_0}{c}\right)^2 - 2\frac{E_1 \cdot E_0}{c^2} \cdot \cos\theta$$

"No free lunch" energy:

$$E_0 + mc^2 = E_1 + \sqrt{m^2c^4 + p^2c^2}$$

$$(E_0 - E_1 + mc^2)^2 = m^2c^4 + p^2c^2$$

$$\underline{E_0^2 + E_1^2} - 2E_0E_1 + \underline{m^2c^4} + 2(E_0 - E_1)mc^2 = \underline{m^2c^4} + \underline{p^2c^2}$$

From momentum eq: $\times c^2$

$$\underline{E_0^2 + E_1^2} - 2E_0E_1 \cdot \cos\theta = \underline{p^2c^2}$$

substract the two:

$$2(E_0 - E_1)mc^2 = 2E_0E_1(1 - \cos\theta)$$

$$\frac{1}{E_1} - \frac{1}{E_0} = \frac{1 - \cos\theta}{mc^2}$$

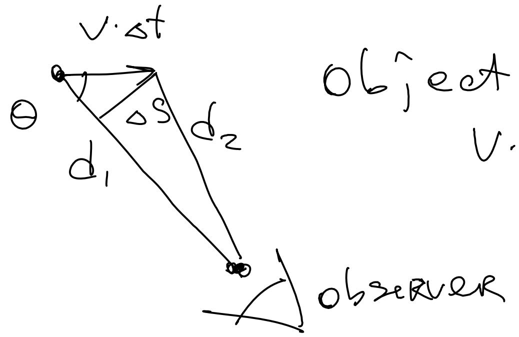
$$E = h\nu = h\frac{c}{\lambda} \Rightarrow \frac{1}{E} = \frac{\lambda}{hc}$$

$$\frac{\lambda_1}{hc} - \frac{\lambda_0}{hc} = \frac{1 - \cos\theta}{mc^2}$$

$$\lambda_1 - \lambda_0 = \frac{h}{mc}(1 - \cos\theta)$$

$$\lambda_1 - \lambda_0 = \frac{h}{mc}(1-\cos\theta)$$

**12.6**




Object travels $v \cdot \Delta t$

observer "observes" motion

$$\Delta S = v \cdot \Delta t \cdot \sin\theta$$

time between two photons is

$$\Delta t' = \Delta t - \frac{d_1 - d_2}{c} = \Delta t - \frac{v \cdot \Delta t \cdot \cos\theta}{c}$$

Observed velocity is

$$u = \frac{\Delta S}{\Delta t'} = \frac{v \cdot \Delta t \cdot \sin\theta}{\Delta t - \frac{v \cdot \Delta t \cdot \cos\theta}{c}} = \frac{v \cdot \sin\theta}{1 - \frac{v\cos\theta}{c}}$$

Could easily be $> c$

**12.7** In muon's F.O.R. lifetime is $\gamma t$

$$v = \frac{d}{\gamma t} = \frac{d}{t}\sqrt{1-\left(\frac{v}{c}\right)^2}$$

$$\left(\frac{v}{c}\right)^2 = \left(\frac{d}{ct}\right)^2 \cdot \left(1-\left(\frac{v}{c}\right)^2\right)$$

$$\left(\frac{v}{c}\right)^2 = \frac{1}{1+\left(\frac{ct}{d}\right)^2}$$

$$v = \frac{c}{\sqrt{1+\left(\frac{ct}{d}\right)^2}} = 0.8\,c$$

**12.17**

$$\bar{a}^0 = \gamma(a^0 - \beta a^1)$$
$$\bar{a}^1 = \gamma(a^1 - \beta a^0)$$
$$\bar{a}^2 = a^2$$
$$\bar{a}^3 = a^3$$

$$-\bar{a}^0\bar{b}^0 + \bar{a}^1\bar{b}^1 + \bar{a}^2\bar{b}^2 + \bar{a}^3\bar{b}^3 =$$

$$= -\gamma^2(a^0 - \beta a^1)(b^0 - \beta b^1) +$$

$$+ \gamma^2(a^1 - \beta a^0)(b^1 - \beta b^0) + a^2b^2 +$$

$$+ a^3b^3 = -\gamma^2(a^0b^0 - \beta a^1b^0 - \beta a^0 b^1 +$$

$$+ \beta^2 a^1b^1 - a^1b^1 + \beta a^0b^1 + \beta a^1 b^0 - \beta^2 a^0b^0) +$$

$$+ a^2b^2 + a^3b^3 = -\gamma^2(a^0b^0 - a^1b^1)\underbrace{(1-\beta^2)}_{1/\gamma^2} +$$

$$+ a^2b^2 + a^3b^3 = -a^0b^0 + a^1b^1 + a^2b^2 + a^3b^3$$